Laboratory researchers bridge the super-conductivity gap

by Todd Hanson

Laboratory scientists working with a researcher from Chonnam National University in South Korea have found that magnetic fluctuations appear to be responsible for superconductivity in a compound called plutonium-cobalt-pentagallium (PuCoGa5). The discovery of this "unconventional superconductivity" may lead scientists to a whole new class of superconducting materials and toward the goal of eventually synthesizing "room-temperature" superconductors.

In research reported in a recent edition of the scientific journal Nature, Nicholas Curro of Condensed Matter and Thermal Physics (MST-10) and a team of researchers provide evidence of how magnetic fluctuations, rather than interactions mediated by tiny vibrations in the underlying crystal structure, may be responsible for the electron pairing that produces superconductivity in the mixture of plutonium, cobalt and gallium.

Superconductivity is an unusual state of matter in which electrical current flows without resistance through a material as a result of the material's electrons acting in pairs. Since the discovery at Los Alamos of PuCoGa5 roughly two years ago, a burning question has been whether the compound was just another garden-variety superconductor, a so-called s-wave superconductor, or an unconventional one that is mediated by magnetic fluctuations, a d-wave superconductor.

Although the temperatures at which superconductivity is observed are usually quite low, a handful of compounds like PuCoGa5 have been found to possess superconductivity at temperatures warmer than minus 427 degrees Fahrenheit. Even though that temperature seems low, PuCoGa5 possesses highest superconducting transition temperature among actinide based compounds found so far. This "unconventional superconductivity" suggests that PuCoGa5 may be one of a very small handful of superconductors whose superconductivity actually derives from magnetic correlations.

Scientists theorize that having found one unconventional superconductor like PuCoGa5, they may find more in the future. Making the research even more intriguing is the fact that plutonium is a base actinide material of the compound. This new class of magnetically mediated superconductors might encompass a broad range of materials, metals to oxides, and be the path toward superconductor science's ultimate goal to someday synthesize a "room-temperature" superconductor that would be the basis for the dissipation-less flow of electric current through power lines, and for an even more minute generation of computer chips.

The discovery is the result of collaboration between the Materials Science and Technology (MST), Nuclear Materials Technology (NMT) and Theoretical (T) divisions. In addition to Curro, the team includes Tod Caldwell, Eric Bauer, Joe Thompson and John Sarrao of MST-10; Luis Morales of Nuclear Materials Science (NMT-16); Matthias Graf and Alexander Balatsky of Condensed Matter and Statistical Physics (T-11); and Yunkyu Bang of Chonnam National University, South Korea.

Technology Maturation Fund

What is the Technology Maturation Fund?

The Technology Maturation Fund is a grant program managed by the Technology Transfer (TT) Division. The fund supports Laboratory technologies identified to have high commercial potential. The intent of the fund is to move promising technologies to the proof-of-concept or prototype stage to attract potential licensees or investors interested in funding a startup company or commercializing a new technology. The Technology Maturation Fund acts similar to a venture capital fund. However, instead of investing in start-up companies, funds are invested in internal technologies.

What should an employee know about the Tech Mat Fund before applying?

- Funds are allocated from the University of California prime contract through Appendix M, and a portion of TT retained license income.
- Approximately $450,000 is available in Technology Maturation funds each year.
- Awards are made in amounts up to $50,000 per project/milestone.
- Proposals are accepted throughout the year; the fund-review panel meets once a month.
- Proposals are reviewed by a panel of TT staff.
- Funds are awarded based on the commercial potential, not scientific merit, of the technology.
- Tech Mat funding is exempt from G&A. However, Organizational Support is applied.

What else should be considered before applying for Tech Mat funding?

- Funds allocated may not be used to substitute or increase funding from other sources already funded by Department of Energy or Work-for-Others programs. Employees should contact their business team leader if there is a question.
- Awards will be treated as advances on license revenue and a repayment schedule will be developed.
- Work must be conducted in accordance with the Laboratory's Integrated Safety Management requirements.
- Foreign National participation must be approved by Foreign Visits and Assignments and disclosed on form 982, "Unclassified Visit or Assignment by a Foreign National."

How does an employee apply for a Tech Mat award?

To apply, Laboratory researchers submit a short proposal describing their technology and its market potential. Proposal applications are available at the Technology Transfer Web site at *www.lanl.gov/partnerships* online. For more information, contact Erica Sullivan, Technology Maturation Fund administrator, at 7-9219 or *eab@lanl.gov* by e-mail.

Successful experiment…

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Experimentation (DX), Engineering Sciences and Applications (ESA), Applied Physics (X), Manufacturing Systems and Methods (MSM), Physics (P), Materials Science and Technology (MST), Chemistry (C), Security and Safeguards (S) and Performance Surety (PS).

The experiment demonstrates that Los Alamos can do major hydrodynamic experiments such as this one, sub-critical and small-scale experiments, and research, development and testing of high explosives in support of the Laboratory's mission.

The first axis of DARHT has been providing high-quality images to NNSA's stockpile stewardship program since late 1999 in several hydrodynamic experiments and dozens of smaller high-explosives experiments, all of which have provided images of unprecedented resolution and clarity.

At DARHT, electron accelerators produce intense, penetrating X-ray beams that, like a flash bulb, can freeze the motion of objects moving at explosively driven speeds of more than 2,000 miles an hour. Electrons used for the snapshot are accelerated to energies of 20 million volts, and are converted to X-rays that expend that energy in just 60-billionths of a second. The second axis at DARHT, when completed, will enable stereoscopic and time-sequenced views of hydrodynamic experiments.

The next hydrodynamic experiment in the current series at DARHT is scheduled for this summer.